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# Irrigation Return Flow Quality

# South Columbia Basin Irrigation District

# May-August 1980

by

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## INTRODUCTION

During the summer of 1980 the Water and Wastewater Monitoring Section of the Department of Ecology (DOE) monitored water quality in irrigation return flows to the Columbia River from the South Columbia Basin Irrigation District. The objectives of this study were: (1) determine return flow quality and quantity; and (2) evaluate the return's impact on the Columbia River. Selected returns from this irrigation district had been sampled by the section in June-July 1977 and May 1978. The results of the 1980 survey follow.

## STUDY AREA DESCRIPTION

Figure 1 shows the location of major wasteways and irrigation canals in the South Columbia District. The source of irrigation water for this area (in addition to wells) is Scooteney Reservoir which collects water from the East Columbia and Quincy districts. Water for the Columbia Basin Project is initially diverted at Grand Coulee Dam.

Approximately 390 square miles in this district are under irrigation for production of alfalfa, asparagus, corn, potatoes, orchard crops, and grapes. Application of irrigation water is almost exclusively by sprinkling. Soils are sandy with low slopes and high percolation rates.

The wasteways monitored were Esquatzel Coulee (river mile 344), Pasco (river mile 345.5), PE 16.4 (river mile 355), and WB-5 (river mile 357). Ringold Springs just above PE 16.4 also was sampled. These springs supply water for the Department of Game's Ringold steelhead hatchery. All wasteways flow year-around with minimal flows occurring early and late in the year and consisting primarily of ground water. Irrigation water is brought in early May and is off by the end of October. Flow characteristics for each wasteway can be summarized as follows[1]:

Esquatzel Coulee - Spring flows average 5 to 10 cfs; high average of 125 cfs during August; 40 to 50 cfs for remainder of year.

Pasco Wasteway - Early and late flows average 10 cfs; averages 25 cfs during irrigation season.

PE 16.4 Wasteway - Flows always above 45 cfs; yearly average of 100 cfs; irrigation season 150 to 200 cfs.

WB-5 Wasteway - About 10 cfs November to March; 60 to 70 cfs average during irrigation season.

[1]Personal communication, South Columbia Basin Irrigation District water masters Julius Brandt, Don Olsen, and Jim Sommers.

Two other wasteways, Saddle Mountain and WB-10, drain northern portions of the district but were not sampled. Irrigation return flows reach the Columbia River via Saddle Mountain Wasteway during August, but little or no flow exists for the remainder of the year. WB-10 Wasteway water does not reach the Columbia River.

## SURVEY METHODS

The wasteways were sampled at their mouths by surface grabs once a month over a one-to-two-day period from May through August. At each return, from one to six samples were taken for each parameter measured, depending on sample variability and significance to water quality. Where more than one sample per month was collected, an attempt was made to sample at intervals over 24 to 48 hours.

Temperature, pH, specific conductivity, and dissolved oxygen (D.O.) were measured in the field. The parameters listed below were measured from samples placed on ice and returned to the DOE Tumwater laboratory for analysis according to Methods for Chemical Analysis of Water and Wastes, EPA 1977.

1. Total Kjeldahl-nitrogen (TKN)
2. Total ammonia-nitrogen ($[NH_3+NH_4]$-N)
3. Nitrite-nitrogen ($NO_2$-N)
4. Nitrate-nitrogen ($NO_3$-N)
5. Orthophosphate-phosphorus (O-$PO_4$-P)
6. Total phosphate-phosphorus (T-$PO_4$-P)
7. Total suspended solids (TSS)
8. Turbidity (NTU)
9. Chemical oxygen demand (COD)
10. Biochemical oxygen demand, 5-day ($BOD_5$)
11. Fecal coliform (col/100 ml)
12. Total alkalinity (mg/L)
13. Total hardness (mg/L)
14. Chloride (mg/L)
15. Sulfate (mg/L)

Wasteway flow data were supplied by the irrigation district. Esquatzel Coulee and PE 16.4 Wasteway were gaged during the May sample collection and the results agreed well with the district's data. Ringold Springs was gaged once each sampling period.

On August 12, 1980 a series of samples was taken in the Columbia River and analyzed for temperature, specific conductivity, nutrients, turbidity, and total suspended solids. Temperature and conductivity measurements also were made around the mouths of several wasteways in an attempt to define plume size.

## RESULTS AND DISCUSSION

### Return Flow Quality

The survey data collected are summarized in Table 1. The wasteways differed from one another primarily in volume, PE 16.4 Wasteway and Esquatzel Coulee being the largest. Water quality was consistent between returns with the exception of low specific conductance (a measure of dissolved solids concentration) and nitrate-nitrogen in Pasco Wasteway, probably reflecting the lower re-use rate of this water.[2] Constituent concentrations for most parameters were slightly higher in WB-5 Wasteway. This may be the result of its being the only return that is earth-lined in its terminal portion. Groundwater from Ringold Springs is shown to be substantially different in character, as compared to the irrigation returns, in its high dissolved solids content and low temperature, pH, organic nitrogen, suspended solids, and turbidity. Nitrate-nitrogen concentrations were highest here, as would be expected.

Table 2 shows these returns to be of good quality when compared to established water quality criteria. With the exception of temperatures, which were often high, these waters were usually at or near Class A stream standards. Most parameters ranged within limits protective of aquatic life. In fact, a small but active sport fishery exists at the points where these returns enter the Columbia River. Suitability for use in irrigation remained high although this water is subject to recycling in its course through the irrigation districts.

Nitrate-nitrogen concentrations were above the potential algal bloom threshold of 0.3 mg/L[3] in all samples collected. Nuisance growths of algae have not, however, been a serious problem in the district. Orthophosphate-phosphorus concentrations were uniformly low and are probably a limiting factor.

## Impact to the Columbia River

Results from this survey support the findings of the 1977-78 DOE sampling program (Appendix A) which suggested that for most constituents these returns are too low in volume and concentration to adversely impact water quality in the Columbia River (minimum dilution ratios were estimated at about 300:1 for the August 1980 low-flow period).

The relative wasteway contributions of nitrate-nitrogen, total phosphate-phosphorus, and total suspended solids to the Columbia River are estimated in Table 3. Phosphate and solids are clearly not significant. Nitrate-nitrogen loading from Esquatzel Coulee and Pasco Wasteway is, however, substantial. These calculations indicate that, taken collectively, South Columbia District return flows increase nitrate loading in the river by about 50 percent during irrigation season. This assumes nitrate behaves conservatively and is, therefore, likely to overestimate the actual increase. The end result, however, of even a 50 percent increase in nitrate-nitrogen should be continued relatively low concentrations below the district's returns, given the low upriver nitrate levels on which these loading calculations are based.

[2]Personal communication, Russell Smith, Manager, South Columbia Basin Irrigation District.

[3]Klein, L., 1959. River Pollution. Academic Press, Inc., N.Y. 206 pp.

These conclusions are supported by river water samples collected on August 12 during a period of low river flow and maximum return flows. In a series of samples from above WB-5 Wasteway to below Esquatzel Coulee (see Table 4) nitrate-nitrogen remained at 0.01 to 0.02 mg/L. Similarly, total phosphate-phosphorus and total suspended solids remained low and essentially unchanged throughout this same reach of the river.

The Yakima and Snake rivers immediately downstream of the South Columbia Basin Irrigation District wasteways probably exert an overriding influence on Columbia River water quality as shown by the loading calculations in Table 5.

In the immediate vicinity of each wasteway outfall, dispersion and dilution are rapid. Temperature and conductivity transects made during this survey and in June-July 1977 showed that the "plume" from even the largest wasteway, PE 16.4, could not be traced more than 100 to 200 meters downstream.

## WPRS Historical Data

Since 1962 the Water and Power Resources Services (formerly Bureau of Reclamation) has been conducting a water sampling program in the Columbia Basin project. The terminal portions of Esquatzel Coulee, Pasco Wasteway, PE 16.4 Wasteway, and WB-5 Wasteway are included in this sampling network. These data have been reviewed to develop a description of seasonal and historic changes in return flow quality.

Figure 2 traces the annual cycles of nitrate-nitrogen, specific conductance, and total suspended solids observed in PE 16.4, the wasteway for which WPRS has the most data. During periods of low flows early in the year the major source of wasteway flow is groundwater high in leached nitrate and other dissolved constituents. With the onset of irrigation, surface return flows probably begin to contribute an increasing proportion of wasteway flows. As a result, water quality during the irrigation season is characterized by higher suspended solids concentrations and relatively lower amounts of nitrates and dissolved solids. As irrigators cut back on water use with the coming of fall, subsurface return flows again become the dominant influence on wasteway quality.

Historical trends in the WPPS data are not as self-evident. The most complete sequences of data are again for nitrate and specific conductance in PE 16.4 Wasteway. These data are graphed in Figure 3 and separated by season because of the basic differences in hydrology described above. These data suggest that conductance and nitrate were at a low in the early 70's and have generally been on the increase up to the present time. Concentrations of both parameters, as measured in the mid to late 60's, appear equal to or greater than present-day concentrations. These data may not accurately reflect the return's historical changes in quality since (1) each year is represented by one sample only, and (2) the ranges in nitrate and conductance observed in PE 16.4 Wasteway during the brief May-August 1980 survey were equal to between one-third and one-half the extremes shown in this historical record.

## SUMMARY AND CONCLUSIONS

The major findings from this survey of South Columbia Basin Irrigation District wasteway quality are as follows:

1. The four wasteways sampled differ from one another primarily in volume; PE 16.4 and Esquatzel Coulee being the largest at 60 to 190 cfs during the irrigation season.

2. Water quality for most parameters is comparable between wasteways. Pasco Wasteway water is somewhat lower in dissolved solids and nitrate-nitrogen as it is subject to less re-use. WB-5 Wasteway is highest in nutrients, suspended solids, and turbidity.

3. Overall wasteway quality is good when compared to state Class A stream standards and criteria for protection of aquatic life and use in irrigation.

4. Nitrate-nitrogen concentrations are above the potential algal bloom threshold of 0.3 mg/L in all wasteways. Orthophosphate-phosphorus concentrations, however, are low.

5. The high dilution capacity of the Columbia River minimizes impacts of these returns on the Columbia River. The major return flow input is nitrate-nitrogen.

6. Nutrient and suspended solids loading rates for these returns are one to two orders of magnitude less than in the Yakima and Snake rivers tributary to the Columbia River and immediately downstream.

7. Nitrate-nitrogen and dissolved solids are at relatively high levels in these wasteways during the early and late parts of the year when groundwater flow predominates. During the irrigation season, suspended solids increase with increased surface return flows while concentrations of dissolved constituents are reduced.

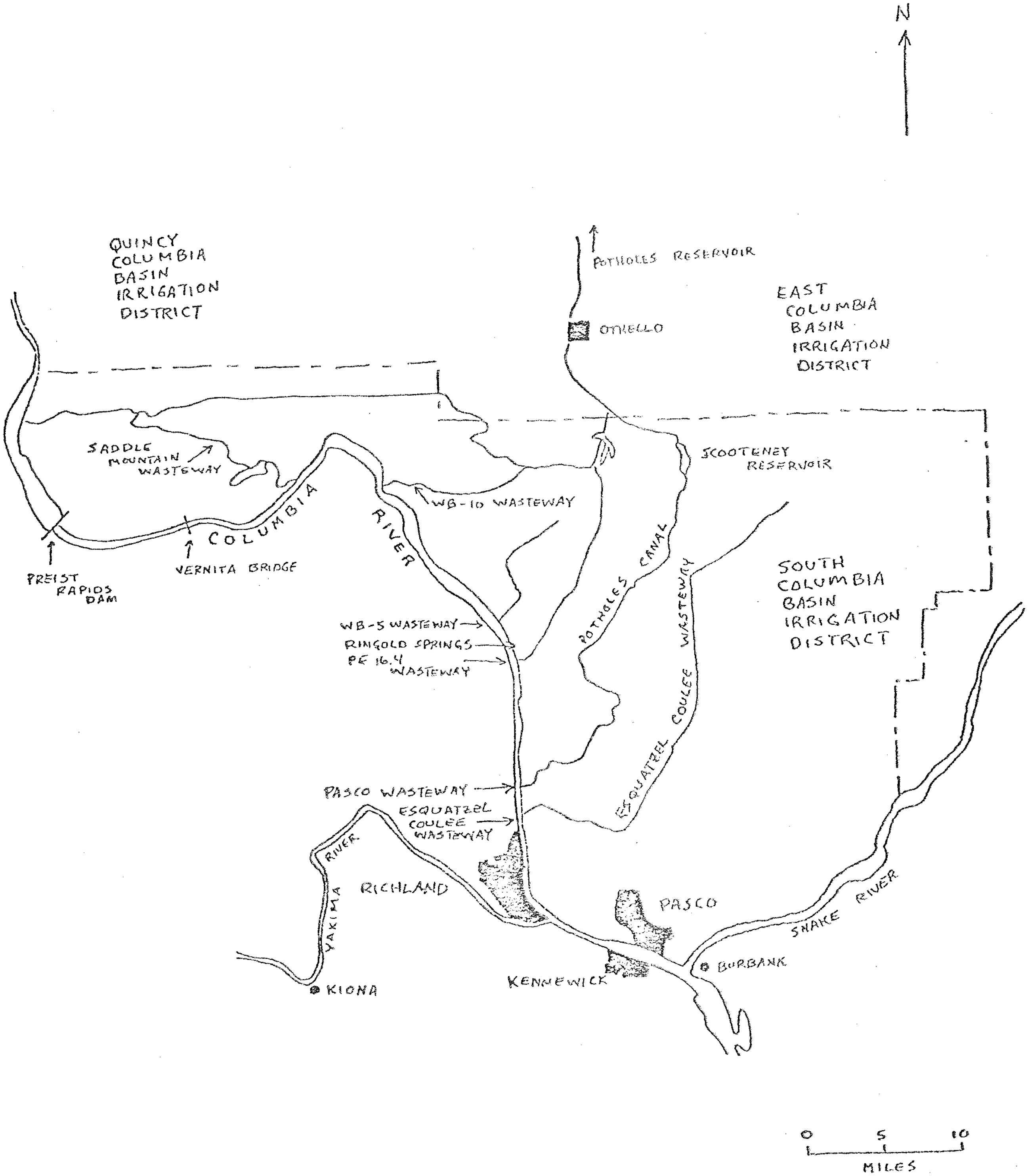


Figure 1. South Columbia Basin Irrigation District and Vicinity.

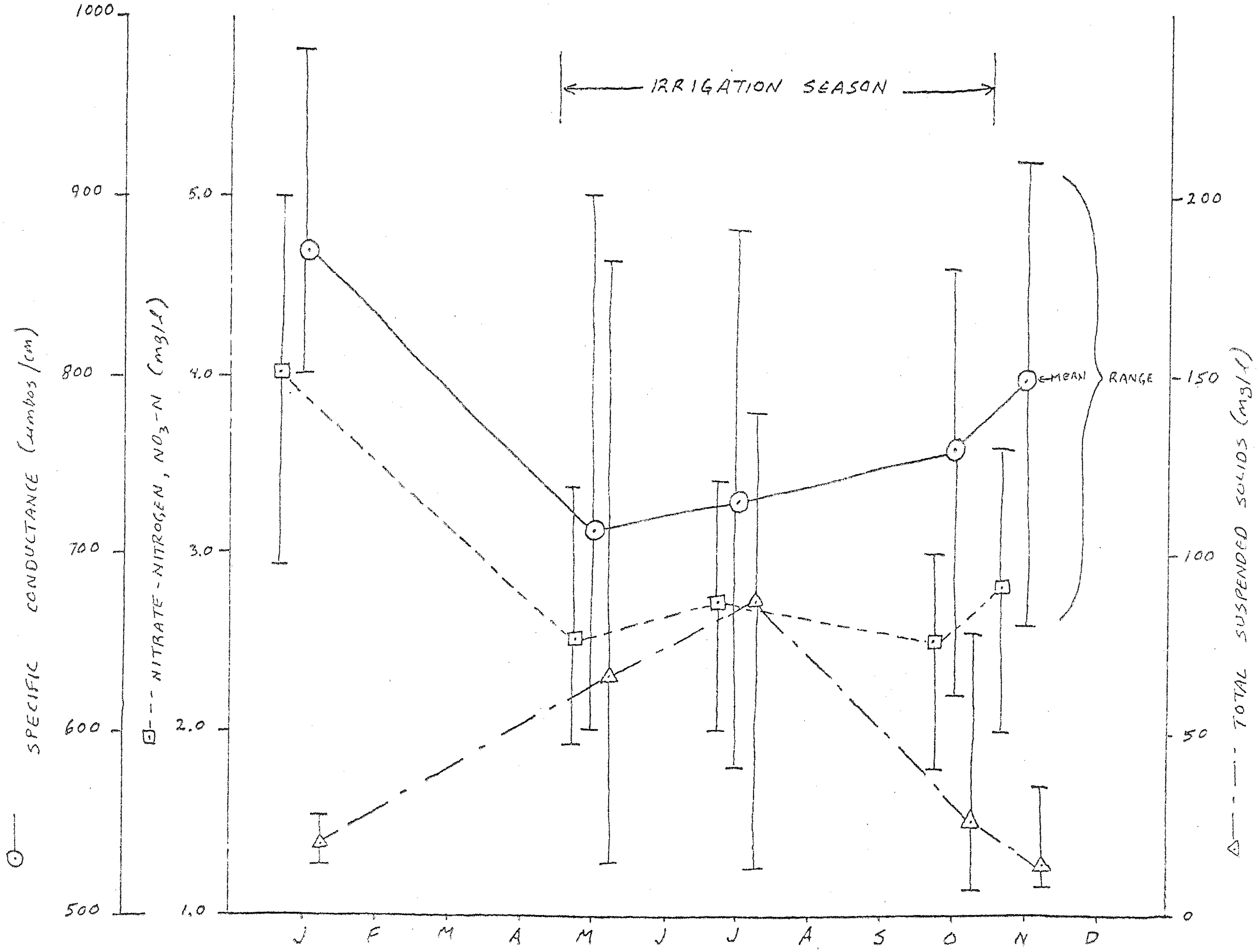


Figure 2. Seasonal Changes in Specific Conductance, Nitrate-nitrogen, and Total Suspended Solids in PE 16.4 Wasteway, South Columbia Basin Irrigation District (from WPRS data collected 1964-1980 conductance, 1968-1980 nitrate, 1973-1980 solids).

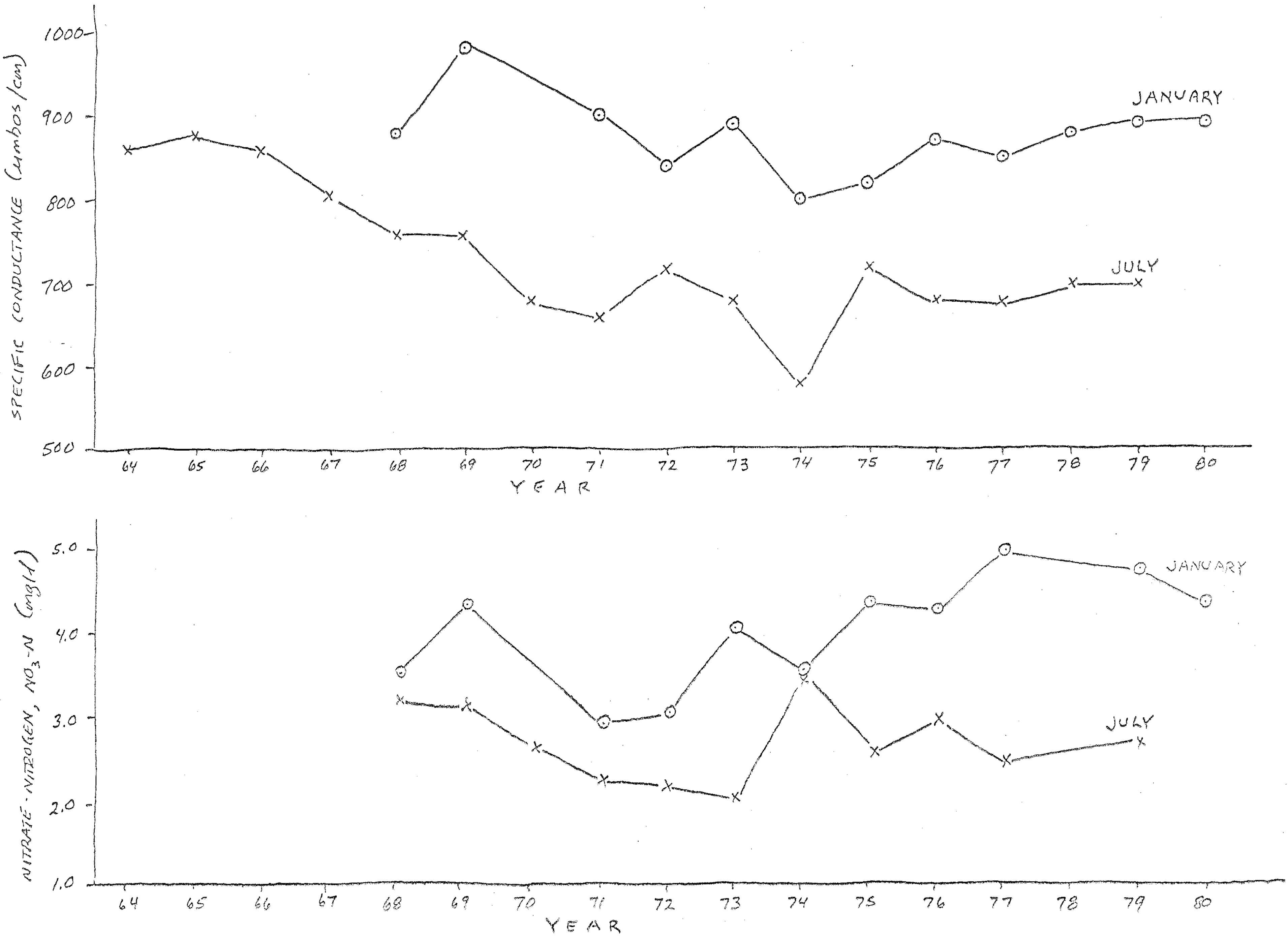


Figure 3. Yearly Changes in Specific Conductance and Nitrate-nitrogen in PE 16.4 Wasteway (WPRS data, each data point represents a single sample).

ble.1. Irrigation Return Flow Quality, South Columbia Basin Irrigation District, May-August 1980[a].

| | Esquatzel Coulee | | | Pasco Wasteway | | | PE 16.4 Wasteway | | | WB-5 Wasteway | | | Ringold Springs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rameter | Mean | Range | Number of Samples | Mean | Range | Number of Samples | Mean | Range | Number of Samples | Mean | Range | Number of Samples | Mean | Range | Number of Samples |
| ow[b] (cfs) | 90 | 60-130 | -- | 31 | 21-42 | -- | 171 | 154-190 | -- | 42 | 43-48 | -- | 25 | 22-33 | -- |
| mp. (°C) | 21.1 | 15.3-24 | 14 | 22.5 | 16.4-27.0 | 14 | 20.7 | 15.5-25.0 | 14 | 22.7 | 18.3-27.0 | 10 | 18.1 | 16.8-20.0 | 8 |
| | 8.6 | 8.3-8.9 | 14 | 8.8 | 8.6-8.9 | 14 | 8.5 | 8.4-8.7 | 14 | 8.7 | 8.5-9.0 | 10 | 8.3 | 8.2-8.4 | 8 |
| . Conductance ($\mu$mhos/cm) | 595 | 550-645 | 14 | 415 | 400-425 | 14 | 645 | 600-705 | 14 | 645 | 610-700 | 9 | 920 | 900-990 | 8 |
| N (mg/l) | .66 | .51-.80 | 3 | .68 | .42-.91 | 4 | .51 | .34-.72 | 4 | .72 | .38-.97 | 3 | .06 | .04-.08 | 2 |
| $H_3$+$NH_4$)-N (mg/l) | .01 | <.01-.02 | 10 | .02 | <.01-.08 | 14 | .01 | .01-.04 | 14 | .04 | .02-.09 | 8 | .02 | <.01-.04 | 8 |
| $_3$-N (mg/l) | 3.0 | 2.7-3.2 | 13 | .99 | .85-1.3 | 14 | 3.0 | 2.4-3.8 | 14 | 4.5 | 3.3-5.6 | 8 | 4.7 | 4.3-4.9 | 8 |
| $_2$-N (mg/l) | <.01 | <.01-.01 | 13 | <.01 | <.01-.01 | 14 | <.01 | <.01-.01 | 14 | <.01 | <.01-.02 | 7 | <.01 | all <.01 | 8 |
| $PO_4$-P (mg/l) | <.01 | <.01-.01 | 10 | <.01 | <.01-.03 | 14 | <.01 | <.01-.03 | 14 | .02 | <.01-.04 | 8 | <.02 | <.01-.04 | 8 |
| $PO_4$-P (mg/l) | .04 | .01-.06 | 9 | .05 | .01-.06 | 12 | .05 | .01-.07 | 12 | .05 | .04-.06 | 6 | .05 | .02-.06 | 5 |
| S (mg/l) | 15 | 8-29 | 10 | 30 | 13-83 | 14 | 20 | 8-33 | 14 | 48 | 29-55 | 8 | 5 | 4-6 | 7 |
| rb. (NTU) | 5 | 2-8 | 13 | 7 | 5-14 | 14 | 5 | 4-6 | 14 | 12 | 6-19 | 8 | 1 | 1-2 | 8 |
| D (mg/l) | 19 | 4-29 | 6 | 24 | 16-28 | 6 | 25 | 21-29 | 6 | 44 | 20-110 | 4 | 43 | 20-66 | 2 |
| $D_5$ (mg/l) | 4 | <2-4 | 6 | 4 | 3-7 | 6 | 3 | 2-6 | 6 | 3 | 2-<4 | 4 | <3 | <2-<4 | 2 |
| O. (mg/l) | 10.9 | 9.9-11.9 | 4 | 9.8 | 8.7-10.7 | 4 | 10.2 | 9.6-10.8 | 4 | 9.8 | 9.1-10.5 | 3 | 10.5 | 10.3-10.7 | 2 |
| cal Coliform (col/100 ml) | 108[c] | 2-320 | 7 | 29[c] | 18-54 | 7 | 64[c] | 44-220 | 7 | 83[c] | 30-170 | 4 | 49[c] | 43-54 | 2 |
| Alkalinity (mg/l) | 180 | 170-190 | 4 | 135 | 130-140 | 6 | 180 | 180-190 | 6 | 190 | 190-200 | 4 | 220 | 210-220 | 2 |
| Hard. (mg/l) | 210 | 200-220 | 4 | 160 | 140-170 | 6 | 235 | 220-250 | 6 | 230 | 220-250 | 4 | 330 | all <.01 | 2 |
| loride (mg/l) | 17 | 11-20 | 4 | 11 | 10-11 | 6 | 22 | 20-24 | 6 | 19 | 17-21 | 4 | 38 | 32-43 | 2 |
| fate (mg/l) | 66 | 57-72 | 4 | 41 | 31-50 | 6 | 92 | 85-96 | 6 | 80 | 71-85 | 4 | 155 | 150-160 | 2 |

ata compiled from samples collected on May 6-7, June 16-17, July 21-22, and August 11-12.
low data supplied by South Columbia Basin Irrigation District except Ringold Springs which was gaged at time of sample collection.
edian.

Table 2. Water Quality in South Columbia Basin Irrigation District Wasteways Compared to Quality Criteria for Washington State, Protection of Aquatic Life, and Irrigation Use.

| Parameters | South Columbia District Wasteways | | Washington State Class A Standard[a] | Protection of Aquatic Life[b] | Irrigation Use[c] |
|---|---|---|---|---|---|
| | Mean | Range | | | |
| Temp. (°C) | 21.8 | 15.3-27.0 | ≤18 | -- | -- |
| pH | 8.7 | 8.3-9.0 | 6.5-8.5 | 6.5-9.0 | 4.5-8.4 |
| D.O. (mg/l) | 10.2 | 8.7-11.9 | >8.0 | >5.0 | -- |
| Turb. (NTU) | 7 | 2-19 | <5 above bkg. | -- | -- |
| Fecal Coliform (col/100 ml) | 71[d] | 2-320 | <100 (median) | -- | -- |
| $(NH_3+NH_4^+)$-N (mg/l) | .02 | <01-.09 | -- | <.02 ($NH_3$-N) | -- |
| $NO_2$-N (mg/l) | <.01 | <.01-.02 | -- | <.06 (salmonids) | <10 (livestock) |
| $NO_3$-N (mg/l) | 3.8 | .85-5.6 | -- | <90 | -- |
| TSS (mg/l) | 28 | 8-83 | -- | <25 (high protection)<br><80 (moderate protection) | --<br>-- |
| T. Alkalinity (mg/l) | 175 | 130-200 | -- | >20 | -- |
| Sp. Conductance (μmhos/cm) | 575 | 400-705 | -- | -- | <750 |
| Chloride (mg/l) | 17 | 11-24 | -- | -- | <142 |
| Sulfate (mg/l) | 70 | 31-96 | -- | -- | No effect except in conjunction with dissolved solids above acceptable range. |

[a]State of Washington, 1978. Washington State Water Quality Standards.

[b]USEPA, 1976. Quality Criteria for Water.
Am. Fish. Soc, 1979. A Review of the EPA Redbook: Quality Criteria for Water.

[c]Bureau of Reclamation, 1975. Effects of Irrigation and Storage on Water Quality.

[d]Median.

Table 3. South Columbia Basin Irrigation District, Estimated Return Flow Loading Rates to the Columbia River for Nitrate-nitrogen, Total Phosphate-phosphorus, and Total Suspended Solids, May-August 1980.[a]

| | Flow | NO3-N | | | T-PO4-P | | | TSS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | cfs | mg/l | lbs/day | % of Columbia River | mg/l | lbs/day | % of Columbia River | mg/l | lbs/day | % of Columbia River |
| **MAY** | | | | | | | | | | |
| Columbia River | 147,300 | .05 | 39,800 | -- | .06 | 47,700 | -- | 6 | 4,770,000 | -- |
| Esquatzel Coulee | 75 | 3.0 | 1,210 | 3 | .05 | 20 | <1 | 25 | 10,100 | <1 |
| Pasco Wasteway | 32 | .90 | 155 | <1 | .05 | 9 | <1 | 65 | 11,200 | <1 |
| PE 16.4 Wasteway | 162 | 2.8 | 2,450 | 6 | .05 | 44 | <1 | 29 | 25,400 | <1 |
| WB-5 Wasteway | 42 | 3.3 | 748 | 2 | .06 | 14 | <1 | 54 | 12,200 | <1 |
| Ringold Springs | 22 | 4.8 | 570 | 1 | .06 | 7 | <1 | 5 | 594 | <1 |
| Combined Returns | | | 5,130 | 13 | | 94 | <1 | | 59,500 | 1 |
| **JUNE** | | | | | | | | | | |
| Columbia River | 134,200 | .01 | 7,250 | -- | .03 | 21,700 | -- | 5 | 3,623,000 | -- |
| Esquatzel Coulee | 60 | 3.0 | 972 | 13 | .03 | 10 | <1 | 13 | 4,210 | <1 |
| Pasco Wasteway | 32 | 1.2 | 207 | 3 | .03 | 5 | <1 | 14 | 2,420 | <1 |
| PE 16.4 Wasteway | 156 | 2.7 | 2,270 | 31 | .03 | 25 | <1 | 14 | 11,800 | <1 |
| WB-5 Wasteway | 45 | 4.2 | 1,020 | 14 | .05 | 12 | <1 | 51 | 12,400 | <1 |
| Ringold Springs | 22 | 4.8 | 570 | 8 | .02 | 2 | <1 | 6 | 713 | <1 |
| Combined Returns | | | 5,040 | 69 | | 54 | <1 | | 31,500 | <1 |
| **JULY** | | | | | | | | | | |
| Columbia River | 125,600 | .02 | 13,600 | -- | .04 | 27,100 | -- | 5 | 3,390,000 | -- |
| Esquatzel Coulee | 100 | 3.1 | 1,670 | 12 | .04 | 22 | <1 | 11 | 5,940 | <1 |
| Pasco Wasteway | 39 | .89 | 187 | 1 | .05 | 11 | <1 | 21 | 4,420 | <1 |
| PE 16.4 Wasteway | 175 | 2.8 | 2,650 | 20 | .07 | 66 | <1 | 16 | 15,100 | <1 |
| WB-5 Wasteway | 43 | 4.8 | 1,110 | 8 | .06 | 14 | <1 | 36 | 8,360 | <1 |
| Ringold Springs | 23 | 4.5 | 559 | 4 | .05 | 6 | <1 | 4 | 497 | <1 |
| Combined Returns | | | 6,180 | 45 | | 119 | <1 | | 34,300 | <1 |
| **AUGUST** | | | | | | | | | | |
| Columbia River | 116,200 | .03 | 18,800 | -- | .05 | 31,400 | -- | 6 | 3,765,000 | -- |
| Esquatzel Coulee | 130 | 2.9 | 2,040 | 11 | .05 | 35 | <1 | 12 | 8,430 | <1 |
| Pasco Wasteway | 22 | .99 | 118 | <1 | .05 | 6 | <1 | 20 | 2,380 | <1 |
| PE 16.4 Wasteway | 190 | 3.6 | 3,690 | 20 | .05 | 51 | <1 | 18 | 18,500 | <1 |
| WB-5 Wasteway | 39 | 5.5 | 1,160 | 6 | .04 | 8 | <1 | 52 | 11,000 | <1 |
| Ringold Springs | 33 | 4.5 | 802 | 4 | .05 | 9 | <1 | 5 | 891 | <1 |
| Combined Returns | | | 7,810 | 41 | | 109 | <1 | | 41,100 | 1 |

Table 4. Columbia River Water Quality Above and Below South Columbia Basin Irrigation District Wasteways, August 12, 1980

| Sampling Site | Temp. (°C) | Specific Conductance ( mhos/cm) | Turb. (NTU) | $NO_3$-N (mg/l) | T-$PO_4$-P (mg/l) | TSS (mg/l) |
|---|---|---|---|---|---|---|
| Above WB-5 Wasteway | 19.7 | 145 | 2 | .01 | .03 | 2 |
| Above Ringold Springs | 20.0 | 150 | 1 | .01 | .03 | - |
| Above PE 16.4 Wasteway | -- | 140 | - | -- | -- | - |
| 0.1 Mile Below PE 16.4 Wasteway | 19.8 | 140 | 3 | .01 | .03 | 4 |
| 4 Miles Below PE 16.4 Wasteway | 19.5 | 140 | -- | .01 | .03 | - |
| 7.5 Miles Below PE 16.4 Wasteway | 19.5 | 150 | - | .02 | .03 | 3 |
| Above Pasco Wasteway | 19.7 | 155 | 1 | .03 | .03 | 3 |
| Above Esquatzel Coulee | 20.5 | 160 | - | -- | .03 | - |
| 0.1 Mile Below Esquatzel Coulee | 19.8 | 160 | 2 | .01 | .03 | 6 |
| 1 Mile Below Esquatzel Coulee | 20.3 | 150 | 1 | .02 | .03 | 4 |

Table 5. South Columbia Basin Irrigation District, Estimated Return Flow Loading Rates for Nitrate-nitrogen, Total Phosphate-phosphorus, and Total Suspended Solids Compared to the Yakima and Snake Rivers, May-August 1980.

| | Flow | $NO_3$-N | | T-$PO_4$-P | | TSS | |
|---|---|---|---|---|---|---|---|
| | cfs | mg/l | lbs/day | mg/l | lbs/day | mg/l | lbs/day |
| **MAY** | | | | | | | |
| South Columbia Returns | 333 | 2.9[a] | 4,980 | .05 | 95 | 33 | 59,500 |
| Yakima River[b] | 5,300 | 5.6 | 160,000 | .43 | 12,300 | 65 | 1,860,000 |
| Snake River[b] | 108,000 | 2.7 | 1,580,000 | .12 | 70,200 | 33 | 19,320,000 |
| **JUNE** | | | | | | | |
| South Columbia Returns | 315 | 3.0 | 5,040 | .03 | 54 | 19 | 31,500 |
| Yakima River | 2,900 | 9.1 | 142,000 | .54 | 8,450 | 18 | 282,000 |
| Snake River | 108,000 | 7.6 | 4,410,000 | .12 | 69,700 | 10 | 5,800,000 |
| **JULY** | | | | | | | |
| South Columbia Returns | 380 | 3.0 | 6,180 | .06 | 119 | 17 | 34,300 |
| Yakima River | 1,730 | -- | -- | -- | -- | -- | -- |
| Snake River | 41,400 | 4.1 | 916,000 | .06 | 13,400 | 18 | 4,023,108 |
| **AUGUST** | | | | | | | |
| South Columbia Returns | 414 | 3.5 | 7,810 | .05 | 109 | 18 | 41,100 |
| Yakima River | 1,640 | -- | -- | -- | -- | -- | -- |
| Snake River | 20,400 | 2.0 | 220,000 | .06 | 6,600 | 23 | 2,530,000 |

[a] Average for all returns.

[b] Flow and constituent concentration data from USGS routine monitoring station 12510500 at Kiona on the Yakima River and 13353200 at Burbank on the Snake River. Flows are monthly means; concentrations represent results from one or two samples each month.

Appendix A. Irrigation Return Flow Quality, South Columbia Basin Irrigation District, June and July 1977, and May 1978.[a]

| Parameter | Esquatzel Coulee | | | Pasco Wasteway | | PE 16.4 Wasteway | | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 6/77 | 7/77 | 4/78 | 6/77 | 7/77 | 6/77 | 7/77 | 4/78 |
| Flow (cfs) | 54 | 154 | | 59 | 34 | 196 | 152 | |
| Temperature (°C) | 19.0 | 18.0 | | 21.2 | 22.0 | 18.0 | 18.0 | |
| pH | 8.4 | 8.5 | 8.7 | 8.6 | 8.7 | 8.3 | 8.2 | 8.7 |
| Sp. Conductance (μmhos/cm) | 580 | 500 | 661 | 380 | 430 | 730 | 700 | 633 |
| TKN (mg/l) | | .50 | .59 | | .39 | | | 1.0 |
| $(NH_3+NH_4)$-N (mg/l) | <.02 | <.02 | <.02 | <.02 | .03 | <.02 | <.02 | <.02 |
| $NO_2$-N (mg/l) | <.02 | .02 | <.02 | <.02 | <.02 | <.02 | <.02 | <.02 |
| $NO_3$-N (mg/l) | 3.1 | 2.0 | 3.1 | .73 | .94 | 3.1 | 2.2 | 2.4 |
| O-$PO_4$-P (mg/l) | <.02 | .02 | <.02 | <.02 | .02 | <.02 | .02 | <.02 |
| T-$PO_4$-P (mg/l) | <.02 | .04 | <.02 | .05 | .06 | <.02 | .04 | .04 |
| TSS (mg/l) | | 12 | 15 | | | 14 | | 28 |
| Turb. (NTU) | 3 | 6 | 5 | 14 | 6 | 3 | 6 | 10 |
| COD (mg/l) | | 32 | 22 | | 24 | | 32 | 22 |
| $BOD_5$ (mg/l) | | 3 | 3 | | 3 | | <2 | 2 |
| Fecal Coliform (col/100 ml) | | | 25[b] | | | | | 32[b] |
| T. Hardness (mg/l) | | | 200 | | | | | 220 |
| T. Alkalinity (mg/l) | | | 220 | | | 211 | 190 | 190 |
| Chloride (mg/l) | 26 | | | 12 | 14 | 31 | 28 | |
| Sulfate (mg/l) | 80 | 62 | | 38 | 38 | 110 | 98 | |

[a]Each data point represents a single sample.

[b]Estimate.